Innovation and trade in the presence of credit constraints

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Abstract. This paper examines how trade liberalization affects investment in R&D at the firm level. We provide a model with entrepreneurs that differ in their wealth endowments, causing them to rely on external funds to different extents. In the presence of capital market imperfections, this implies heterogeneous access to external financing such that poor entrepreneurs run smaller firms, are less likely to invest in R&D and are more likely to exit the market. Decreasing trade costs resulting from tariff reductions exacerbate these characteristics. Using firm-level panel data on seven Latin American countries for 2006 and 2010, we find support for our theoretical predictions. While prior research emphasizes a positive impact of trade liberalization on firms' productivity-enhancing activities, we provide novel evidence showing that financial constraints can impair the effect on R&D efforts. These results suggest that imperfect capital markets can prevent welfare gains from trade liberalization to materialize.

Résumé. Innovation et commerce en présence de contraintes de crédit. Cet article étudie la façon dont la libéralisation des échanges a des répercussions sur l'investissement des entreprises en recherche et développement. Nous proposons un modèle dans lequel les entrepreneurs ne disposent pas des mêmes ressources financières et dépendent, à des degrés divers, de financements externes. En présence d'imperfections sur le marché des

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capitaux, cela suppose un accès hétérogène au financement externe : les entrepreneurs économiquement faibles à la tête de petites entreprises sont moins susceptibles d'investir en recherche et développement et sont davantage enclins à se retirer du marché. La diminution des coûts commerciaux consécutive à la baisse des tarifs douaniers accentue ces caractéristiques. Nous corroborons nos prévisions théoriques en utilisant des données de panel au niveau des entreprises de sept pays d'Amérique latine pour les années 2006 et 2010. Tandis que les recherches précédentes insistent sur les conséquences positives de la libéralisation des échanges sur les activités visant à améliorer la productivité des entreprises, nous proposons de nouveaux éléments montrant que l'effet sur les efforts en recherche et développement peut être altéré par les contraintes financières. Ces résultats suggèrent que l'imperfection des marchés de capitaux peut empêcher les gains de bien-être favorisés par la libéralisation des échanges de se matérialiser.

JEL classification: F14, O12, O16

1. Introduction

A large body of trade literature provides empirical support for the superior performance characteristics of exporting firms relative to non-exporters (e.g., Bernard and Jensen 1999, Bernard et al. 2007).[1] One particular explanation for this superiority points to a complementarity between firms' exporting status and their investment in productivity-enhancing activities. Investigating this link follows a key insight by Schmookler (1966) that inventors channel their efforts into those lines of activity with high prospective profits. If the size of any market that firms operate in becomes larger, potential profits increase and so do firms' R&D-related efforts. This can be linked to trade policy in the sense that any removal of trade frictions effectively enlarges the size of the market firms are serving. Operating in a globalized market makes it more profitable for firms to invest in R&D as a means to remain competitive and capture a large share of the international market.

We examine both theoretically and empirically the decision of firms who operate under financial constraints to invest in R&D when tariff rates change. We believe this set-up to be of particular interest because some firms may not capture the increased market size due to trade liberalization if credit constraints restrict their ability to adjust the production. Thus, financial constraints affect not only the financing of fixed costs but the firm operations as well. Previous research by Banerjee (2004) and Banerjee and Duflo (2014) documents the importance of credit constraints for small and medium-sized enterprises in developing countries. Aghion et al. (2012) and Gorodnichenko and Schnitzer (2013) show theoretically that financial frictions affect a firm's decision to invest in innovative activities in a closed economy set-up. In their empirical contribution, Aghion et al. (2012) find that French firms' R&D

1 Similarly, for the import side of international trade, prior research has documented a positive correlation between productivity and importing (cf. Abreha 2017).

investment turns procyclical in the presence of binding credit constraints. We augment this argument and illustrate how trade liberalization can worsen access to finance for small firms, thereby affecting innovative activities. Poor entrepreneurs in our model are particularly susceptible to trade openness because reducing tariff protection has heterogeneous effects across firms. While unconstrained enterprises increase their innovative activities, credit-rationed firms—which are, in general, small or medium-sized—either cut spending on R&D or leave the market altogether.

Our research adds to several recently published studies documenting the so-called market size effect on innovation with respect to trade liberalization. Bernard et al. (2006) show that US manufacturing industries exhibit strong productivity growth after experiencing large declines in trade costs. Atkeson and Burstein (2010) provide a general equilibrium model and show how trade liberalization affects firms' decision to invest in R&D. For a sample of Argentinean firms, Bustos (2011a,b) documents that tariff reductions were associated with technology upgrading. Aw et al. (2007) and Aw et al. (2011) also consider research investment and exporting behaviour as joint decisions. Using plant-level data from Taiwan, they find evidence that both activities increase productivity.[2] Finally, Lileeva and Trefler (2010) draw on Canadian firm-level data and provide evidence that after a reduction in tariff rates, firms that started exporting or exported more increased their productivity and became more innovative.

This literature, however, has been largely silent about firm-level responses to trade liberalization in the presence of imperfect capital markets. Traditional trade theory assumes that resources are allocated efficiently across firms by means of a well-functioning capital market. While this takes into account that firms face upfront expenses for production and R&D efforts, it abstracts from capital market imperfections found in most developing economies.[3] Recent advances in trade theory incorporate credit constraints (Bonfiglioli et al. 2019). A survey of this literature is provided by Foley and Manova

2 Verhoogen (2008) finds similar evidence in a panel data set on Mexican manufacturing plants. Bloom et al. (2016) use data on 12 European countries and show that import competition with China fostered innovation. In a related study, Costantini and Melitz (2008) build a dynamic model of plant-level adjustments to trade liberalization capturing the joint innovation and exporting decision, selection into exporting and learning-by-exporting. Empirically, Coelli et al. (2020) provide support for a positive effect of trade liberalization on innovation in a sample of 100 countries.

3 Aghion et al. (2010) analyze the implications of financial frictions with respect to volatility and growth. They provide theoretical and empirical support for adverse effects of credit constraints on long-term investment. More recently, Segerstrom and Sugita (2015) show that, in a multi-industry version of the Melitz (2003) model, industrial productivity increases more strongly in non-6liberalized industries.

(2015). In particular, lacking access to capital can preclude some firms from engaging in trade, although this could be profitable (Manova 2013, Manova et al. 2015). This adverse effect of financial frictions is particularly severe in sectors with high dependency on external finance (Rajan and Zingales 1998).

We further contribute to a number of recent papers that study the effect of credit constraints in international trade models. This includes Egger and Keuschnigg (2015), who explore theoretically how early-stage R&D earnings determine finance constraints and thus innovative activity.[4] Our analysis suggests that trade liberalization alters economic incentives—in particular with respect to innovation and R&D—for companies in emerging economies. While previous research shows that tariff policy affects quality choice among firms (Fan et al. 2015a, Ciani and Bartoli 2020), our model suggests that this is a more generic feature when capital market imperfections are present. Adding to previous research, we show both theoretically and empirically how trade liberalization in developing countries affects both credit constraints and innovative activity.

To understand how the interrelation of financial market imperfections and trade affect firm decisions, we follow previous work by Foellmi and Oechslin (2010, 2020) but introduce an R&D decision of firms. In particular, we assume that entrepreneurs differ in their initial wealth endowments. As a result, poor firm owners must rely on external finance for their business activities. In doing so, they use their local monopoly power as a collateral. However, after trade liberalization, the decline in markups and the rise in interest rates limit their ability to borrow. While trade liberalization would induce them to adjust their production, investment is restricted by financial constraints. This gives rise to two results. First, innovation is limited in the sense that we observe smaller investments in R&D among financially constrained firms exposed to tariff reductions. Second, severely credit-constrained firms are likely to leave the market after trade liberalization.

In addition to our theoretical work, we examine empirically the responses of firms to trade liberalization conditional on a number of firm and market characteristics that may explain heterogeneous behaviour. We focus on the combined effect of financial constraints and tariff reductions on market exit and several R&D-related activities. The latter are measured by product and process innovations as well as filed patents over a three-year period. For our empirical analysis, we use a novel data set on seven Latin American countries for the years 2006 and 2010. We merge firm survey data from the World Bank's Enterprise Surveys with tariff data from the World Integrated Trade Solution database. The former contains a large set of variables on firm characteristics, while the latter allows us to apply a precise measure of treatment for

4 In an earlier paper, Sutton (2007) presents a theoretical model that links trade liberalization to firm-level productivity in the absence of credit market imperfections. Empirically, this link is explored by Kugler and Verhoogen (2012).

each firm on the four-digit ISIC classification level. Our data set is preferable to those used in many other studies because it contains direct measures of innovation and financial constraints. Hence, we do not have to rely on proxies for outcome and treatment variables in the econometric specification.[5] Furthermore, self-reported measures of financial constraints have been documented to strongly correlate with objective indicators of access to credit (Gorodnichenko and Schnitzer 2013).

Although tariff reductions in our data have a positive impact on productivity-enhancing activities, we find evidence showing that credit constraints, in part, drive firms' responses to liberalization. The results indicate that tariff cuts worsen small and medium-sized firms' access to finance. Furthermore, financially constrained firms experience substantial declines in annual sales when subject to tariff reductions. In line with Pierce and Schott (2018), we also find that market exit is more pronounced among financially constrained firms. Our estimates suggest that a tariff reduction for these firms is associated with a significant increase in the probability of leaving the market. Moreover, we find that, among surviving firms, those reporting financial constraints in the initial period are associated with a lower probability of introducing innovative products or production processes if they are subject to trade liberalization. These findings are in line with our theory and are shown to be robust to the inclusion of various control variables as well as country and industry fixed effects. Moreover, the results are not driven by any single country or by an underlying correlation of firm size and credit constraints. Furthermore, the results are similar when using simple average or weighted average tariff rates, and the impact is generally magnified in less-developed countries.

Our work adds another dimension to the literature on how financial constraints distort reallocations within firms after trade liberalization. In this, we contribute to recent studies by Hsieh and Klenow (2009) and by Song et al. (2011), who examine how credit market frictions lead to resource misallocation in low-income countries. At the macro level, Caselli (2012, 2013) shows that, among developing countries, gains from trade openness depend inversely on the degree of wealth inequality prior to liberalization. Closely related to our work, Chesnokova (2007) presents a model with necessary investment and credit constraints. In this model, specialization after trade liberalization can be welfare-reducing if specialization in agriculture affects the wealth distribution such that credit constraints become more binding. Amiti and Weinstein (2011) examine firm-specific shocks to trade finance supply in the setting of

5 We examined the correlation between lending interest rates and the share of firms declaring to be credit-constrained. Using data from the IMF for the years 2006 to 2010—the time horizon of the our WBES data, we find a weak positive correlation. In countries like Argentina where the lending rate increased, the share of firms reporting to be financially constrained increased as well.

Japan's systemic crises from 1990 to 2010. Their findings suggest that liquidity shocks hurt firms' export growth even more than domestic sales.

We also contribute to previous research on international trade and product choice. Acemoglu and Zilibotti (2001) document that firms in poor economies generally tend to produce fewer innovative goods. Hence, these firms typically adjust their production after liberalization (Fieler et al. 2018, Fan et al. 2015b). In particular, exporting firms in low-income countries produce higher-quality goods for export than for the domestic market (Verhoogen 2008). While producing superior quality could be a result of better access to inputs too, it requires R&D investment. Hence, innovative firms may be exposed to higher survival risks if they do not retain diversified sources of finance (Fernandes and Paunov 2015). Our paper adds to these studies, suggesting that imperfect capital markets can be a source of market exit and limited product upgrading after trade liberalization.

The different strands of the literature lead to our hypothesis that access to finance plays a key role in determining firm-level responses to trade liberalization. We investigate this relationship by considering two observable firm decisions: market exit and productivity-enhancing activities. Our theoretical model predicts less product upgrading and increased market exit among credit-constrained firms that are subject to trade liberalization. The empirical results in our paper support these predictions. Adjustments after liberalization appear to be impaired at the firm level if access to finance is limited. Both theoretically and empirically, these findings add to previous work by Peters and Schnitzer (2015). In addition, we contribute to research following Aghion et al. (1999) who show that in the presence of limited borrowing capacities, the distribution of wealth affects firms' production possibilities.

The remainder of the paper is organized as follows. In section 2, we present our theoretical model to illustrate the impact of capital market frictions in a setting of heterogeneous firms facing trade liberalization. Section 3 describes our data set and provides descriptive statistics. Our empirical strategy and the results are shown in section 4. The final section concludes and discusses policy implications.

2. Theory

2.1. The set-up

The model, in particular the design of the credit market, follows Foellmi and Oechslin (2020). We consider a static economy, populated by a continuum of (potential) entrepreneurs with population size 1. The individuals are heterogeneous with respect to their initial capital endowment ω_i with $i \in [0, 1]$. The capital endowments are distributed according to the distribution function $H(\omega)$. Aggregate capital endowment, $\int_0^\infty \omega dH(\omega)$, is denoted by K.

Each individual owns a specific skill (a "business idea") that makes him a monopoly supplier of a single differentiated good. All goods are produced with a simple technology that requires physical capital as the only input in production. To highlight our channel working through heterogeneous endowments, we assume that all producers have access to the same technology. We assume that (here we follow, for example, Melitz 2003) starting production needs a fixed outlay of f capital units. Formally, the production function reads $y_i = a(k_i - f)$, where a is a productivity parameter and y_i and k_i respectively denote output and capital invested. In addition to the initial business idea, the entrepreneur has the option to invest in R&D. To model it in the simplest way, R&D takes only the form of vertical innovations in the form of quality upgrading (in subsection 2.5, we discuss the similar outcome when firms undertake process innovations instead). An innovation requires additional $f(q-1)$ capital units and raises the quality of the product q_i from level 1 to $q > 1$.[6]

The individuals' utility function takes the familiar CES form, and consumers treat the two different quality versions of a good j as perfect substitutes:

$$U = \left[\int_0^1 \left(c_{1j} + q c_{qj} \right)^{(\sigma-1)/\sigma} dj \right]^{\frac{\sigma}{\sigma-1}}, \ \sigma > 1, \tag{1}$$

where $c_{\cdot j}$ denotes consumption of good j at quality level 1 or q. Each individual i maximizes the objective function (1) subject to the budget constraint:

$$\int_0^1 \left(p_{1j} c_{1j} + p_{qj} c_{qj} \right) dj = m(\omega_i), \tag{2}$$

where $p_j(q_j)$ is the price of good j (for quality 1 or q) and $m(\omega_i)$ refers to individual i's nominal income depending on the initial capital endowment, ω_i.

Because both quality levels have the same marginal costs in production, we may simplify the exposition assuming that $p_{1j} \leq p_{qj}/q$. Under these conditions and if only one quality per good j is consumed, individual i's demand for good j reads

$$c_j(m(\omega_i),\ p_j(q_j),\ q_j) = q_j^{-1} \left(\frac{p_j(q_j)/q_j}{P} \right)^{-\sigma} \frac{m(\omega_i)}{P}, \tag{3}$$

where $P \equiv \left[\int_0^1 p_{1j}^{1-\sigma} dj \right]^{1/(1-\sigma)}$ is the familiar CES price index.

Individuals take the equilibrium borrowing rate as given but there may be credit constraints. The reason for an upper bound on borrowing is the imperfect enforcement of credit contracts. Following Foellmi and Oechslin (2020), we assume that—in case of default—borrower i loses only a fraction $\lambda \in (0,$

6 Empirical support for the effect of trade liberalization on product quality upgrading is provided by Fernandes and Paunov (2013) and Fan et al. (2015b).

1] of the current firm revenue, $p(y_i, q_i)y_i$. Hence, the parameter λ indicates how well credit contracts can be enforced.[7] If λ is close to zero, the borrowers do not lose much when they do not honour their debt. In that case, the incentives for lenders are small to provide high levels of external finance.

The lender will give credit only up to the point where the borrower still has an incentive to pay back. Formally, the size of the credit cannot exceed $\lambda p(y_i, q_i)y_i/r$, where r denotes the rental price of capital, i.e., the borrowing rate. Because there is no default in equilibrium, the borrowing rate r must be the same for all agents. To calculate the amount of credit needed, note that you need $k_i = y_i/a + f$ capital units to produce y_i. To produce at quality level q_i additional $f(q_i - 1)$ capital units are needed. With equity ω, you need to borrow $y_i/a + f + f(q_i - 1) - \omega$ capital units. Taking that into account, borrower i will repay the debt if

$$\lambda p(y_i, q_i)y_i/r \geq y_i/a + fq_i - \omega_i. \tag{4}$$

2.2. Effects of international trade

We assume that the home economy is a developing country (the "South"). The trading partner, the rest of the world, is an advanced economy and referred to as the "North." Trade costs take the usual "iceberg" formulation, and we assume that $\tau \geq 1$ units of a good have to be shipped in order for one unit to arrive at the destination. As in Foellmi and Oechslin (2020), we assume that the North differs from the South in that its markets function perfectly. In particular, the northern credit market is frictionless so that there are no credit constraints. Moreover, in the North, each variety in both qualities is produced by a large number of firms so that the northern goods market is perfectly competitive. Regarding access to technology and preferences, there are no differences between the two regions. Further, for the sake of simplicity, the North produces the same spectrum of goods as the South does.

These assumptions imply that all northern firms charge a uniform price for a given quality, equal to the marginal cost. We normalize the northern price level for products of quality q to one. This normalization implies that all goods prices in the North (as well as the northern marginal cost) are also equal to one.

What does this mean for the market structure in the South? Although entrepreneur i has a domestic monopoly, he faces a competitive fringe by Northern producers and cannot set a price above τ when supplying the high quality and τ/q when supplying the low quality. We assume that the market is sufficiently integrated such that all entrepreneurs face the competitive fringe (for cases with intermediate values of τ, see Foellmi and Oechslin 2020).

7 Alternatively, we can assume that the lender can recover only a fraction λ of current profits in case the entrepreneur defaults. Note that we abstain from different types of credit as discussed in Unger (2021).

We are left to determine the borrowing rate. Because we are looking at an equilibrium in which a positive mass of entrepreneurs is credit-constrained and cannot serve the whole market, the economy imports goods from abroad. This, in turn, implies that there must be positive aggregate exports with balanced trade in a static model. The marginal product of capital equals a. Therefore, if an entrepreneur exports one unit of an arbitrary good, this needs τ/a units of capital and generates an income of 1. The entrepreneur compares the return from exporting $(\tau/a)^{-1}$ with the returns when acting as lender on the domestic market. Arbitrage requires, therefore, that the domestic borrowing rate r must equal a/τ.

For credit-constrained firms, the maximum output $\bar{y}$ is determined by $\lambda p(\bar{y},\ q_j)\bar{y}/r \geq \bar{y}/a + fq_j - \omega$, where we use (4) and $p(\bar{y},\ q_j) = \tau q_j/q$. Note that the price the firm can charge is given by $p(\bar{y},\ q_j) = \tau q_j/q$. That is, if the firm invests into quality upgrade it can charge a price of τ, otherwise the price is τ/q. We get $\bar{y} = a(\omega - fq_j)/(1 - \lambda\tau^2 q_j/q)$. Firms not facing the credit constraint serve the whole market. Using (3) and taking into account that high-quality industry output is given by $y_{\max} = q_j^{-1}(\tau/q)^{-\sigma}P^{\sigma-1}Y$, where $P^{\sigma-1}Y$ is uniquely determined in the macroeconomic equilibrium (see Foellmi and Oechslin 2020). To sum up, domestic output in sector j is given by

$$y_j = \min\left\{\frac{a(\omega - fq_j)}{1 - \lambda\tau^2 q_j/q},\ q_j^{-1}(q/\tau)^{\sigma}P^{\sigma-1}Y\right\}. \tag{5}$$

Note that firm output increases in initial wealth for the credit-constrained, poorer entrepreneurs. The reason is the credit market imperfection: an increase in ω means an entrepreneur has more resources to invest and—in addition—it allows for higher borrowing because the entrepreneur has more own collateral that he would lose by not honouring the credit contract. In that sense, $(1 - \lambda\tau^2/q_j)^{-1}$ may be interpreted as credit multiplier. Note that the credit multiplier falls and the firm size of constrained entrepreneurs necessarily falls if τ decreases. This is due to two effects. First, a decrease in trade costs lowers the maximum price monopolists can charge, which erodes profits serving as collateral. Second, a lower τ increases the borrowing rate $r = a/\tau$ because exporting is more attractive. Higher borrowing rates make it more difficult that equation (4) holds.

2.3. Decision on exit and R&D

An entrepreneur seeks to maximize his nominal income, which is given by revenues minus interest payments: $p(y_i,q_i)y_i - r(y_i/a + fq_i - \omega_i) = (1 - \lambda)p(y_i,q_i)y_i$, for active credit-constrained entrepreneurs (using equation (4)). The entrepreneur compares the entrepreneurial income with and without quality upgrading, m_{eq} and m_e, respectively, and the income he would get if he decides to exit and become a lender, earning $m_l \equiv r\omega = a\omega/\tau$. Thus, he maximizes nominal income:

$$\max_{\{e,\,q\}}\left\{m_{eq}(\omega),\ m_e(\omega),\ m_l(\omega)\right\},$$

where

$$m_{eq}(\omega)=(1-\lambda)\tau\frac{a(\omega-fq)}{1-\lambda\tau^2}$$
$$m_e(\omega)=(1-\lambda)\tau\frac{a(\omega-f)}{q-\lambda\tau^2}$$
$$m_l(\omega)=\frac{a\omega}{\tau}.$$

To have an interesting problem where all three occupations (l,e,eq) are possible outcomes, we make the following assumption on trade costs, which is necessary and sufficient such that occupation e exists.[8] However, proposition 1 on the exit decision would be unaffected.

Assumption 1. *We assume the following condition to hold:* $\tau^2>1+q$.

Given assumption 1, we see directly that $m'_{eq}(\omega)>m'_e(\omega)>m'_l(\omega)$. On the other hand $m_{eq}(0)<m_e(0)<m_l(0)=0$. Hence, the poorest agents will choose to become lenders; for medium levels of ω, agents become entrepreneurs without investing in quality upgrading, and for high levels of ω, the entrepreneurs invest in R&D as well. The critical wealth level ω_1 where agents are indifferent between becoming entrepreneur or lender equals $\omega_1=f(1-\lambda)\tau^2/(\tau^2-q)$. The critical wealth level ω_2 where agents are indifferent between investing into quality or not investing equals $\omega_2=f(1+q-\lambda\tau^2)$. Obviously, occupation e exists only iff $\omega_2>\omega_1$. It is easy to check (by insertion) that $\omega_2>\omega_1$ holds iff $\tau^2>1+q$. The intermediate occupation 1 exists if the gains from being entrepreneur, governed by the competitive fringe τ, are large enough. This is guaranteed by assumption 1.[9]

8 Although the model is not intended to give a quantitative prediction but to render qualitative hypotheses, it makes sense to check whether assumption 1 holds quantitatively. On the one hand, we must keep in mind that trade costs vary a lot across products and industries. On the other hand, the potential size of quality upgrading differs between industries as well. If we consider the estimates for the size of trade costs by Anderson and van Wincoop (2004), assumption 1 is not out of range. Because $q>1$, trade costs must be larger than $\sqrt{2}$. Anderson and van Wincoop obtain a value of 2.70 for average trade costs in industrialized countries, for emerging economies this number is even higher. Obviously, this is a very rough comparison, but it shows that our assumption is at least consistent with that estimate.

9 To see that assumption 1 makes sense quantitatively, note that iceberg costs τ denote overall trade costs in the model. Anderson and van Wincoop (2004) estimate τ to be about 270%. Because we are free to choose the value of $q\geq 1$, there is a broad range of iceberg costs τ compatible with assumption 1.

Intuitively, the product market imperfections make entrepreneurship more profitable than being a lender. Given that entrepreneurship entails fixed costs, this option is preferred to being lender only if the firm is large enough. A fortiori, this argument holds for investment in R&D. Because firm size and wealth are positively correlated with each other, poorer entrepreneurs are more likely to become lenders and less likely to invest in high-quality production.

As shown in figure 1 individuals with an initial endowment below ω_1 decide to be lenders, while those with a larger endowment become entrepreneurs. If the initial endowment is larger than ω_2, individuals become entrepreneurs and invest in quality upgrading.

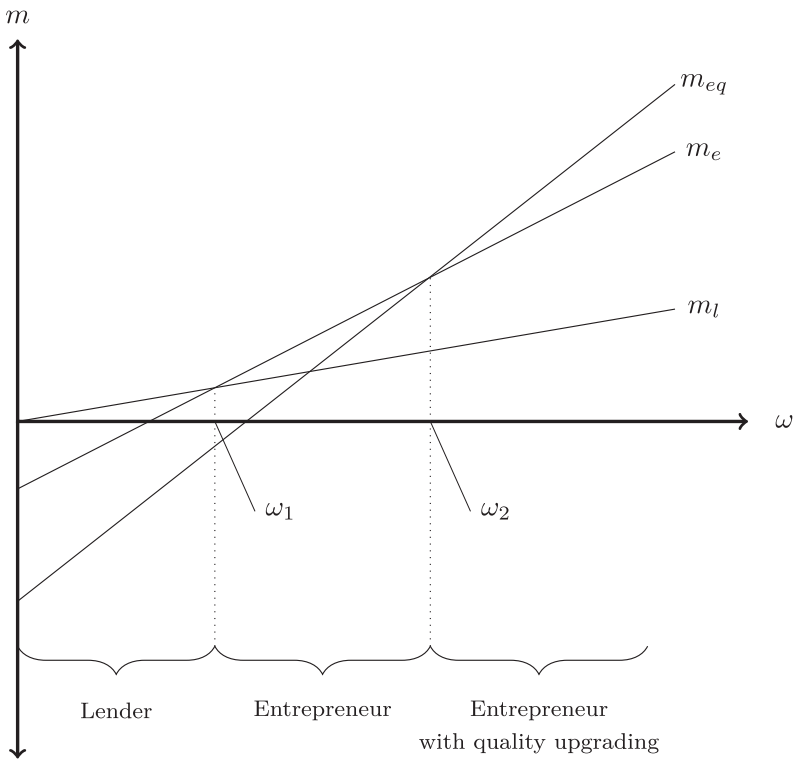

FIGURE 1 Entrepreneurial decisions by endowment
NOTES: The figure illustrates cutoff values for the initial capital endowment, ω, which determine whether individuals become lenders and receive a nominal income of m_l, become entrepreneurs (m_e) or become entrepreneur and invest in quality upgrading (m_{eq}). Individuals with an initial endowment below ω_1 choose to become lenders while those with a larger endowment become entrepreneurs. If the initial endowment is larger than ω_2, individuals become entrepreneurs and invest in quality upgrading.

2.4. Trade liberalization

Let us consider a reduction in trade costs τ. The following two propositions state that financially constrained firms are more likely to exit the market and less likely to invest in R&D when trade liberalization occurs.

PROPOSITION 1. *A decrease in trade costs τ induces severely credit-constrained firms to exit the market.*

Proof. The derivative of ω_1 with respect to τ reads $\partial\omega_1/\partial\tau = -2fq(1-\lambda)\tau/(\tau^2-q)^2 < 0$. A decrease in τ increases the range of entrepreneurs who choose to become lenders. ∎

PROPOSITION 2. *A decrease in trade costs τ reduces investment into quality upgrading by financially constrained firms.*

Proof. The minimum wealth level necessary to invest in quality, $\omega_2 = f(1+q-\lambda\tau^2)$, decreases in τ. A lower level of ω_2 reduces the range of credit-constrained entrepreneurs who invest in R&D. ∎

Note that the relationship between trade costs and the share of credit-constrained firms is non-linear. The threshold values depend on τ^2, the share of active entrepreneurs $1-G(\omega_1)$ and entrepreneurs choosing to innovate $1-G(\omega_2)$ depend on the distribution function. For instance, while the threshold level to invest into R&D by financially constrained firms is concave—tariff reduction have stronger effects than increases, the overall share could be a convex or concave function of the trade costs. This depends on the curvature of $G(\cdot)$.

Things look different for financially unconstrained entrepreneurs. Trade liberalization raises, ceteris paribus, the incentives to invest into quality upgrading. The reason is that, for unconstrained entrepreneurs, the high-quality output increases when trade costs τ fall because market demand is higher with lower prices and, eventually, higher real income due to lower price distortions. A financially constrained entrepreneur, instead, is incapable to serve the full market because of limited access to credit. This market-size effect makes the option to invest in R&D more attractive for the unconstrained entrepreneur. The income of a financially unconstrained entrepreneur, producing high-quality products, is given by

$$(q/\tau)^{\sigma-1}P^{\sigma-1}Y-(a/\tau)\left(q^{-1}(q/\tau)^{\sigma}P^{\sigma-1}Y/a+fq-\omega\right). \tag{6}$$

Income when producing low-quality is given by

$$(q/\tau)^{\sigma-1}P^{\sigma-1}Y-(a/\tau)\left((q/\tau)^{\sigma}P^{\sigma-1}Y/a+f-\omega\right). \tag{7}$$

The difference between the two expressions equals $(a/\tau)(q^{-1}(q/\tau)^{\sigma}P^{\sigma-1}Y/a-f)(q-1)$. Hence, the incentive to invest in high quality rises when $\tau^{-\sigma}P^{\sigma-1}Y$ is larger.

Gross capital supply equals demand in the capital market equilibrium condition:

$$K = [1 - G(\omega_3)]\left[q^{-1}(q/\tau)^{\sigma} P^{\sigma-1} Y/a + fq\right] + \int_{\omega_2}^{\omega_3} \left[\frac{\omega - fq}{1-\lambda\tau^2} + fq\right] dG(\omega) + \int_{\omega_1}^{\omega_2} \left[\frac{\omega - f}{1-\lambda\tau^2/q} + f\right] dG(\omega),$$

where $\omega_3 = fq + (1-\lambda\tau^2) q^{-1}(q/\tau)^{\sigma} P^{\sigma-1} Y/a$ denotes the wealth level such that the entire market demand can be served. When τ falls, the gross capital demand of entrepreneurs falls and more entrepreneurs become lenders. Hence, whenever some entrepreneurs are credit-constrained, $\tau^{-\sigma} P^{\sigma-1} Y$ must rise such that the capital market equilibrium condition holds. Note that it stays constant if all entrepreneurs are unconstrained. The key difference for the constrained entrepreneurs is that the output $y_{\max}(q) = q^{-1}(q/\tau)^{\sigma} P^{\sigma-1} Y$ increases when trade costs τ fall because market demand is higher with lower prices and eventually higher real income. A financially constrained entrepreneur, instead, is incapable to serve the full market because of limited access to credit. The rise in firm output makes the option to invest in R&D more attractive for the unconstrained entrepreneur. Thus, propositions 2 and 3 predict opposing effects of trade liberalizations for financially constrained versus unconstrained firms.

Proposition 3. *For firms not facing financial constraints, a decrease in trade costs τ increases the probability to invest in R&D.*

Proof. See text above. ∎

Finally, trade liberalization affects the set of financially unconstrained firms as well. Some firms who have been unconstrained initially become financially constrained with lower trade costs. The following proposition shows that ω_3 the minimum wealth level to serve the entire market demand rises; hence, when trade costs τ fall, the set of unconfirmed firms, $1 - G(\omega_3)$, gets smaller.

Proposition 4. *A decrease in trade costs τ reduces the number of financially unconstrained firms.*

Proof. In the proof of proposition 3, we show that $\partial(P^{\sigma-1} Y \tau^{-\sigma})/\partial\tau < 0$. Because $\omega_3 = fq + (1-\lambda\tau^2) q^{-1}(q/\tau)^{\sigma} P^{\sigma-1} Y/a$, it follows directly $\partial\omega_3/\partial\tau < 0$. ∎

2.5. Discussion and extensions

While our assumptions on the utility function could be easily relaxed, the assumption of fixed costs, or, more generally, increasing returns on the technology side, is key. The basic intuition is quite general: entrepreneurs who are most adversely affected by credit constraints are limited in their entrepreneurial actions. The payoff of the latter typically increases in the market size. However,

financially constrained firms cannot grow as easily as unconstrained ones due to lack of external funds. Because opening up to trade reduces markups and the profit share, the opportunity to export does not increase profits in the same proportion as import competition decreases them. This effect is even stronger for financially constrained entrepreneurs who cannot access finances are their business. Consequently, financially constrained entrepreneurs are less able to take advantage of market opportunities like trade opening as they make the environment more competitive; hence, they are less likely to stay in the market.

Unilateral trade liberalization

As a final point consider the case where the South pursues a unilateral trade liberalization. To analyze such a policy experiment, assume that the South unilaterally lowers trade barriers such that the trade costs from the North to the South equal $\alpha\tau$, with $\alpha < 1$ and the trade costs from South to North still equal τ. Such a move affects only the limit price $p(\bar{y},\ q_j) = \alpha\tau q_j/q$ financially constrained entrepreneurs can charge. The borrowing rate r, however, is unaffected and equals a/τ because it is determined by the returns to capital for Southern exporters. The critical wealth levels read $\omega_1 = f(1-\lambda)\alpha\tau^2/(\alpha\tau^2 - q)$ and $\omega_2 = f(1+q-\lambda\alpha\tau^2)$. Qualitatively, a reduction of α has a similar effect as a reduction in τ. Hence, a unilateral trade liberalization has similar effects on the firm structure as discussed in the propositions above.

Alternatively, if we consider a unilateral trade liberalization in the North, there is no increased import competition and the limit price is unaffected. However, constrained entrepreneurs are still worse off because of increased borrowing costs. A Northern unilateral trade liberalization raises the interest rate in the South because returns to capital for Southern exporters go up. As a result, output and incomes of constrained entrepreneurs fall and lending becomes more attractive. Unconstrained entrepreneurs, instead, gain from improved exporting opportunities. Taken together, unilateral trade liberalizations have similar effects on the firm structure discussed in the propositions above.

Process innovations

The model in section 2 assumed that successful R&D results in a vertical innovation, i.e., a better product. Alternatively, we could envisage a setting where entrepreneurs pursue process innovations. In that case, successful R&D implies a reduction in costs. To see this, consider the following variant of the model above. There is no quality improvement but the firm may invest in process innovation.

Let us assume that starting production needs a fixed outlay of f_i capital units. If the firm invests f_l units of capital, the entrepreneur may start production with a low productivity a_l. As above, the entrepreneur has the option to invest in R&D. If the firm invests a higher overall amount of $f_h > f_l$ units of capital, the firms undertakes a process innovation and can produce with a high productivity $a_h > a_l$. Taken together the production function reads

$y_i = a_j(k_i - f_j)$, where $j \in \{l, h\}$. Using the same assumptions regarding capital market imperfection and trade, we may derive the nominal incomes of entrepreneurs to determine their choice. If we consider an outcome where all technology choices are present, the richer entrepreneurs and exporters will choose to undertake the process innovation. By arbitrage, the interest rate must follow the high productivity level and $r = a_h/\tau$. An entrepreneur undertaking the process innovation earns $(1 - \lambda)\tau a_h(\omega - f_h)/(1-\lambda\tau^2)$, whereas an entrepreneur using the low-productivity technology achieves an income of $(1 - \lambda)\tau a_h(\omega - f_l)/(a_h/a_l - \lambda\tau^2)$. In comparison, lenders earn $a_h\omega/\tau$. In analogy to the model above, we need to restrict the value of τ such that all three occupations are possible outcomes, this is guaranteed by $\tau^2 > a_h/a_l$.

To check how trade liberalization affects investment into R&D by financially constrained firms, we have to calculate the wealth level, $\hat{\omega}_2$ where agents are indifferent between investing into R&D or not. It equals $\hat{\omega}_2 = f_h + (f_h - f_l)(1-\lambda\tau^2)/(a_h/a_l - 1)$. We see directly that a reduction in trade costs τ increases the critical wealth level $\hat{\omega}_2$ and therefore reduces investment into R&D by financially constrained firms. Similar to proposition 4, a decrease in trade costs τ has opposite effects for firms not facing financial constraints. Because market size grows larger for unconstrained firm, the probability to invest in R&D increases.

To conclude, the alternative assumption that firms pursue process innovations yields qualitatively similar predictions to the basic model with quality improvements. The principal intuition is quite robust. Financially constrained firms suffer from increased competition through lower markups and they cannot increase their business because of financial constraints. This lower their incentives to undertake innovations. The benefit of an innovation increases in market size; because innovations entail fixed costs, smaller firms are less likely to undertake them.

3. Data

3.1. Enterprise surveys and tariff data

The World Bank's Enterprise Surveys (WBES) provide firm survey data for more than 135 countries between 2002 and 2014. When conducting the survey, WBES aims to achieve a representative sample of an economy's private sector.[10] We use recent data from seven Latin American countries—Argentina, Bolivia, Chile, Colombia, Paraguay, Peru and Uruguay—where firms were interviewed in 2006 and 2010 with standardized questionnaires. This choice was guided by several criteria. First, a country must participate in the World Bank Enterprise Surveys for two years to allow for a panel data set. Second, countries

10 An extensive description of the survey's methodology (questionnaires, structure, sampling, weights and interview conductors) is provided on the WBES website at `www.enterprisesurveys.org/methodology`.

of Latin America used varying types of trade policy in the past with mixed experiences. Furthermore, financial constraints are prevalent in these countries.[11] The restriction of our sample to Latin America is to ensure a certain homogeneity of countries. Moreover all of these countries are associated with Mercado Común del Sur (MERCOSUR), a common market in South America promoting free trade. We included all countries for which data was available as a panel for two years with a moderate sample size.[12]

Notably, the average firm in our sample has 93 employees and more than one million US dollars in revenue. Each firm was surveyed by means of a standardized questionnaire. This questionnaire covers a wide range of topics, including firm characteristics and detailed information on the constraints that firms perceived as an obstacle to their business activity. We use this information to construct variables on the prevalence of credit constraints and the intensity of competition, market exit and several measures of productivity-enhancing activities. Moreover, we derive a large set of control variables, which are used in all of the regressions.

The information on financial constraints, denoted by CC, is taken from the World Bank Enterprise Survey (WBES) questionnaire. In particular, it is derived from a question containing a list of potential obstacles to doing business.[13] In total, the question lists 16 obstacles, inter alia access to finance, crime, tax administration, tax rates and transportation. Firms are asked which of these obstacles constitute the most binding constraint. This determines our coding of an indicator variable for being financially constrained. If a firm nominates access to finance as the single most important obstacle to their business activity, the financial constraint dummy takes a value of one, otherwise zero.[14] This information is available for both periods 2006 and 2010. In order to identify the joint effect of constraints and liberalization, only the 2006 value for the constraint is used, while the 2010 value is used as an outcome in section 4.1.

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11 Data from the IMF's Financial Development Index Database shows that in 2006, none of the seven countries in our data set had a highly developed financial markets.

12 Note that we excluded Brazilian firms because they were interviewed in different years (2003 and 2009).

13 The question reads, "You have indicated that several obstacles affect the operation of this establishment. Here is a card with the obstacles I mentioned throughout the interview. Please tell me the three that you think are currently the biggest problem, beginning with the worst of all three."

14 As a robustness check, we labelled all firms as credit-constrained that selected access to finance as one of their top three most severe obstacles. The results confirm a positive (negative) correlation between tariff cuts and market exit (innovation) among financially constrained firms.

Finally, the information on firm exit is obtained from the 2010 surveys, which track firms from the first panel round and record information on why firms were unavailable for the second period. The standardized WBES questionnaire allows us to draw on two different statistics for market exit as an outcome. First, exit can be defined as business failure, which was confirmed in the 2010 survey. Alternatively, following a broader definition, we define exit such that it includes firms that could not be contacted in 2010. This does not contain cases of simple relocation or unwillingness to participate. Instead, this type of market exit may be the result of a dead phone line, a new and unknown postal address, or an unregistered business failure. Note that for our estimations, we entirely use the latter definition. Descriptive statistics indicate that only 3% of firms left the market using the strict definition. In contrast, with the broader definition we have about 14% closing their operations. In order to secure a sufficient number of observations we restrict our estimation to the use of this definition of market exit.

We combine the firm survey data with information on import tariff rates from the World Integrated Trade Solution (WITS) database. Using tariff rates from 2006 and 2010 allows us to apply a precise measure of treatment for each individual firm on the four-digit International Standard Industrial Classification (ISIC) level.[15] Hence, we can clearly identify which firms were subject to trade liberalization (i.e., a reduction of tariff protection for their main product) within each country and sector. We do not, however, have information on the provenance and types of inputs that firms use. Thus, we cannot compute firm-specific input tariff levels. However, the survey allows us to identify those firms that use imported inputs and also gives information on whether the inputs were imported directly or indirectly. We use this information as a covariate in our estimations. Furthermore, in section 4.3 we test the robustness of our findings using a proxy variable for input tariffs based on input–output tables.

We drop all observations from retail and services sectors to focus on the manufacturing sector. In total, our data set contains 5,278 observations from seven countries for the years 2006 and 2010. Among these observations, we have 754 firms that were interviewed in both years (balanced panel). The samples were stratified by industry with the main body of observations being from the textiles sector (35%), food sector (30%) and chemicals and paper sector (22%). The majority of panel observations were observed in Argentina (187 firms), Chile (191), Columbia (138) and Peru (123). Fewer observations were sampled in Bolivia (20), Paraguay (25) and Uruguay (70). We interpret these sectoral shares as indicative that our estimation sample is representative for the shares in the whole economy. When conducting the survey, WBES aims to achieve a representative firm-level sample of an economy's private sector. Due to some firms not answering all relevant questions for our empirical

15 For each firm, the ISIC code is derived from data given in the firm survey.

analysis, we compared sector shares in the raw data from WBES with our estimation sample. The results show that there are no substantial differences in terms of geographic locations of firms between the two data samples.

3.2. Descriptive statistics

Based on the seven countries and two years of observation we have a data set with a total of 5,278 unit observations. Table 1 provides summary statistics for all employed variables in the sample. Further summary statistics are provided in table A3 of the online appendix.

TABLE 1
Summary statistics for the panel sample

	ARG	BOL	CHL	COL	PAR	PER	URY	Total
Tariff 2006	0.12	0.07	0.02	0.15	0.08	0.14	0.11	0.10
	(0.05)	(0.01)	(0.01)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)
Tariff 2010	0.14	0.13	0.05	0.15	0.09	0.08	0.11	0.10
	(0.08)	(0.08)	(0.00)	(0.04)	(0.04)	(0.06)	(0.04)	(0.07)
Tariff cut	−0.02	−0.08	−0.03	0.00	−0.01	0.06	0.00	−0.01
	(0.05)	(0.09)	(0.01)	(0.01)	(0.01)	(0.05)	(0.01)	(0.05)
Tariff cut sq.	0.29	1.46	0.07	0.02	0.02	0.58	0.01	0.23
	(0.52)	(1.91)	(0.03)	(0.09)	(0.02)	(1.01)	(0.01)	(0.65)
Credit-constrained 2006	0.12	0.10	0.12	0.11	0.16	0.10	0.07	0.11
Credit-constrained 2010	0.14	0.10	0.15	0.14	0.08	0.07	0.03	0.12
Market exit (non-panel)	0.05	0.21	0.08	0.29	0.10	0.14	0.12	0.14
Product innovation	0.51	0.67	0.56	0.48	0.53	0.65	0.40	0.54
Process innovation	0.55	0.79	0.59	0.42	0.50	0.55	0.33	0.52
File patent	0.25	0.25	0.22	0.22	0.40	0.34	0.34	0.26
Small firm	0.37	0.23	0.31	0.46	0.20	0.33	0.38	0.36
Medium-size firm	0.40	0.38	0.49	0.42	0.40	0.44	0.44	0.44
Firm age	32.62	23.58	31.70	19.84	28.94	23.39	33.58	28.27
Foreign ownership	0.11	0.25	0.09	0.04	0.16	0.08	0.07	0.09
Share main product	0.70	0.73	0.82	0.76	0.76	0.73	0.77	0.76
Share foreign inputs	0.27	0.52	0.40	0.24	0.47	0.35	0.50	0.35
Direct importer	0.55	0.70	0.54	0.32	0.65	0.56	0.66	0.53
Exporter	0.47	0.45	0.31	0.36	0.50	0.49	0.44	0.41
Share of labour cost	0.27	0.29	0.31	0.33	0.40	0.26	0.27	0.30
Competition	0.59	0.39	0.57	0.68	0.66	0.60	0.61	0.60
Employees	116.95	92.70	81.47	65.57	92.78	132.59	50.26	93.47
Log annual sales	13.98	13.66	14.17	13.24	13.94	13.91	13.78	13.85
Observations	374	40	382	276	50	246	140	1,508

NOTES: The table shows descriptive statistics (mean values) for the panel sample of firms surveyed in both 2006 and 2010. Tariff cut is calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. Market exit is defined as business failure including businesses not found in 2010. All three measures of R&D are dummy variables for innovative activity in the three years prior to 2010. Numbers in parentheses indicate standard deviations. ARG = Argentina. BOL = Bolivia. PAR = Paraguay. PER = Peru. URY = Uruguay.

The statistics indicate that there is considerable variation with respect to most variables across the seven countries. With respect to credit constraints the statistics show that about one in eight firms regards access to finance as the biggest obstacle to their business activity. This aggregate share has not changed between the two observed years 2006 and 2010. Table 1 also provides information on the firm characteristics we use as control variables in the estimations. We have deflated all monetary values and converted them from local currencies to 2006 US dollars, using exchange rates are taken from the World Bank Development Indicators. Many trade-related variables increase over time. This includes for example the share of firms that are directly importing goods, the share of foreign imported inputs, or the share of exporters. Depending on the country, between 30% and 70% of firms engage in productivity-enhancing activities.

Concerning trade liberalization we observe that only Peru and Uruguay lowered their tariffs on average *over all industries* between 2006 and 2010. In the case of Peru this is due to the United States–Peru Trade Promotion Agreement (PTPA), signed on April 12, 2006. According to the Office of the United States Trade Representative, the PTPA provides a secure and predictable legal framework for investors, while strengthening protection for intellectual property, workers and the environment. A total of 80% of US exports of consumer and industrial products to Peru became duty-free and the remaining tariffs were set to phase out over ten years.[16] For Uruguay, several bilateral trade agreements with the US were also signed between 2006 and 2008. In contrast, Bolivia shows a significant increase in average tariff rates, which may be due to more protectionist policies following the election of president Evo Morales in January of 2006. Regarding industries, the major tariff reductions we have in our data occurred in the manufacturing sector producing food, beverages, basic chemicals (such as photographic plates, ink or explosives), plastics products and medical appliances and instruments.

We provide information on the seven countries' main trading partners in the online appendix. For all countries in our dataset we find similar main trading partners. China, the United States and the European Union account for a large share of both imports and exports. However, there is substantial variation in the trade balance and the importance of trade among the seven countries. Bolivia, Chile and Paraguay have a very large share of trade in GDP of more than 70%. Argentina shows a large surplus in the trade balance, while Colombia and Peru have large deficits.

For the control variables in our estimation, we use only the 2006 information as well as a variable capturing participation of the firm in the follow-up survey in 2010. There are numerous reasons why firms did not participate in

16 More details on the PTPA are provided on the website of the United States Trade Representative (`www.ustr.gov/trade-agreements/free-trade-agreements/peru-tpa`).

the next round. However, for only nine firms the reason was unknown. Thus, attrition is not an issue for our approach when exit is the dependent variable because we can use the full first-period sample. When R&D-related activities are used as the outcome (which implies that a firm is still operating in 2010), we restrict our sample to a balanced panel of firms. Table 1 provides the respective summary statistics for all relevant variables in this sub-sample.

As noted earlier, follow-up information was not available for many firms for a variety of reasons. This raises the question of how important non-random attrition is in our sample. Overall, the differences with respect to most variables are rather small. Using a simple two-sample t-test, we find a few significant differences at the 5% level. Not surprisingly, the means for credit constraints, competition, market exit, firm size and age are different in the panel and non-panel samples. Some form of non-random attrition can be found in virtually any panel data set and can hardly be corrected for. We use the available information on which firms exited and why (see above reasons) when identifying the effects of trade liberalization and constraints on firms' decisions to engage in R&D-related activities. In a sample in which the most constrained firms are excluded (because of business failure), only considering surviving firms induces a downward bias of our estimates. This does not change the bottom line of our reasoning. Because we expect a negative effect of liberalization on credit-constrained firms' propensity to invest in quality upgrading, the presence of non-random attrition will cause us to *underestimate* the effect. This makes it more difficult to find any significant correlation between credit constraints, tariff reductions and innovative activity.

An important final concern addresses the issue of multi-product firms. Such companies might be less affected by credit constraints when facing changes in trade liberalization because they can more options to adjust. As in the related literature, we observe that multi-product firms are larger in terms of number of employees and more likely to engage in exporting compared to single product firms. However, we cannot assign a unique tariff change to firms producing many different goods. Hence, we restrict our data set to firms that report that their main product accounts for at least 30 per-cent of annual sales. In addition, we control for the share of the main product in all regressions.

4. Empirical results

As shown in section 2, reducing trade costs makes it more difficult for small and medium-size firms to borrow capital. In addition, equation 5 shows that output among credit-constrained firms responds negatively to reduced tariff protection. As a result, we expect to see an increase in the probability of market exit among financially constrained firms in sectors with reduced tariffs. Moreover, investment in R&D-related activities among surviving (financially constrained) firms is expected to decrease.

We use our data set on seven Latin American countries in order to test these predictions. In a first step, we explore empirically whether tariff cuts worsen small firms' access to credit. Furthermore, we test whether annual sales of constrained firms respond negatively to trade liberalization. In the second step, we examine in detail the joint impact of credit constrains and tariff reductions. In particular, we test for the positive effect on market exit and the negative impact on R&D efforts.

4.1. Trade openness and access to credit

One of the key insights of our theoretical model is that trade openness can worsen access to finance for some firms. Due to data limitations we cannot provide a structural estimation of the model. However, we can use our data set to test whether the model's main predictions find empirical support. In a first step, we examine the effect of tariff cuts between 2006 and 2010 on the probability of being credit-constrained in 2010. For this, we follow Foellmi and Oechslin (2020) who used our data set for motivating empirical evidence.

In table 2, we show time trends in the share of firms that report credit constraints as a major obstacle to their business. Using all firms, columns (1) and (2) document a large increase in the share only for those companies that experienced a substantial tariff reduction. As columns (3) to (6) show, this is driven by small and medium-size enterprises.

In order to test whether the difference-in-differences (DiD) is significant, we run a DiD estimation and provide the results in the lower part of table 2. Due to sufficient sample size we can add country and industry fixed effects. Note that industries i are measured at the two-digit ISIC classification, while each firm reports the four-digit ISIC code of its main product. The results support our theoretical model's prediction that tariff reductions increase the share of firms reporting credit constraints as obstacle to their business.[17] Our model also predicts that among financially constrained firms, output is negatively affected by reductions in trade costs (cf. equation 5 in section 2). In table 3, we test this prediction. The regression is given by

$$Y_{j,i,c,t} = \beta_1 Y_{j,i,c,t-1} + \beta_2 \Delta T_{j,i,c,t} + \beta_3 \Delta T^2_{j,i,c,t} + \gamma \mathbf{X}_{j,i,c,t-1} + \mu_c + \delta_i + \varepsilon_{j,i,c,t}, \tag{8}$$

where $Y_{j,i,c,t}$ denotes log annual sales of firm j in industry i and country c in the second period (2010). $\Delta T_{j,i,c,t}$ is the change in tariff rates at the firm level, calculated as the difference between the two periods 2006 and 2010. The specification intends to mimic our theoretical model in which we discuss the implications of reduced tariff protection. Given the size of the tariff

17 The finding that tariff cuts positively affect the share of firms reporting credit constraints is confirmed in a different sample of countries by Irlacher and Unger (2018).

TABLE 2

Tariff cuts and credit constraints (CC)

	All firms		Smaller firms		Larger firms	
	(1)	(2)	(3)	(4)	(5)	(6)
Share of firms CC in 2006	0.075	0.117	0.075	0.122	0.079	0.095
Share of firms CC in 2010	0.128	0.113	0.140	0.125	0.105	0.054
Difference	0.053	−0.004	0.065	0.003	0.026	−0.041
N	133	426	93	352	38	74
Difference-in-differences						
With country FE	0.134**		0.162**		0.045	
	(0.063)		(0.073)		(0.137)	
With country and industry FE	0.121*		0.159**		0.067	
	(0.065)		(0.073)		(0.141)	
Sample: Firms with:	Substantial tariff reduction	No substantial tariff reduction	Substantial tariff reduction	No substantial tariff reduction	Substantial tariff reduction	No substantial tariff reduction

NOTES: The top part of the table shows a comparison of the share of credit-constrained firms in 2006 and 2010. In the lower part, six separate difference-in-differences regressions are shown. In each regression, the change in the share of credit-constrained firms is used as the dependent variable. Columns (1) and (2) include all firms, while columns (3) to (6) use sub-samples according to firm size. Larger firms are those with 100 or more (i.e., with an above-average number of) employees. Odd columns are based on the sample of firms that experienced a substantial tariff reduction for their main product. Tariff cuts are calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. It is considered to be substantial if the reduction was more than 10 percentage points. We obtain similar results with other thresholds. Robust standard errors are shown in parentheses. Significance levels are as follows: *0.10, **0.05, ***0.01. FE = fixed effects.

TABLE 3

Tariff cuts, credit constraints and annual sales

	Log annual sales 2010			
Mean of dependant var.	13.42		14.03	
	(1)	(2)	(3)	(4)
Tariff cut	−0.506	−1.208*	2.448**	0.816
	(0.803)	(0.622)	(0.737)	(0.867)
Tariff cut sq.	−0.117**	−0.108*	0.076**	0.072**
	(0.039)	(0.051)	(0.022)	(0.025)
Log annual sales 2006	0.690***	0.696***	0.861***	0.840***
	(0.078)	(0.077)	(0.056)	(0.049)
Sample	Credit-constrained firms in 2006		Not credit cons. firms in 2006	
Control variables	Yes	Yes	Yes	Yes
Fixed effects	Country	Country, industry	Country	Country, industry
Observations	359	359	1,079	1,079
R-squared	0.781	0.793	0.863	0.870

NOTES: The table shows four separate OLS regressions using different dependent variables as indicated in the top row. In columns (1) to (4) the sample selection depends on whether firms stated access to financing (availability and cost) was a "major" or "very severe" obstacle in 2006. Tariff cut is calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. Control variables include firm size, firm age, foreign ownership, competition and the share of sales of main product. Standard errors are clustered at the country level and shown in parentheses. Significance levels are as follows: *0.10, **0.05, ***0.01.

change, we allow for non-linearities as proposed by the theory. For this aim, we add a squared term of $\Delta T_{j,i,c,t}$ in the regression.

The results are reported in table 3. We find significant evidence that tariff cuts are adversely related to output in 2010 among credit-constrained firms (columns (1) and (2)) but not among unconstrained firms.

4.2. Market exit and R&D

Based on the model in section 2 we expect firms to respond heterogeneously to tariff reductions. Some firms will continue their business and invest resources into quality upgrading, some will cut expenses on R&D efforts and some will exit the market entirely. Therefore, our empirical findings on the joint effects of financial constraints and trade liberalization are split into two parts. We start with an evaluation of the hypothesis developed in our model that a reduction in tariff protection increases credit-constrained firms' propensity to leave the market. Second, we estimate the effect of tariff reductions on surviving firms' propensity of developing innovative products and production processes or filing patents.

4.2.1. Econometric approach

Our estimation uses a cross-section of firms where the effect of interest concerns the interaction term on liberalization and credit constraints. The baseline regression is given by

$$Y_{j,i,c,t} = \beta_1 CC_{j,i,c,t-1} + \beta_2 \Delta T_{j,i,c,t} + \beta_3 \Delta T^2_{j,i,c,t} + \beta_4 CC_{j,i,c,t-1} \times \Delta T_{j,i,c,t} + \beta_5 CC_{j,i,c,t-1} \times \Delta T^2_{j,i,c,t} + \gamma \mathbf{X}_{j,i,c,t-1} + \mu_c + \varepsilon_{j,i,c,t}, \quad (9)$$

where $Y_{j,i,c,t}$ is a dummy variable, capturing the outcome variable obtained from the second period (2010). This can be firm exit, product or process innovation, or filed patents. As in equation (8), $CC_{j,i,c,t-1}$ denotes financial constraints of firm j in industry i and country c in the first period (2006). The change in tariff rates at the firm level, $\Delta T_{j,i,c,t}$, is calculated as the difference between the two periods 2006 and 2010. $\mathbf{X}_{j,i,c,t-1}$ is a vector of control variables including firm size, firm age, foreign ownership, degree of competition, share of main product, foreign input share, being a direct importer, being an exporter and the share of labour cost.[18] The extent of competition in a given product market has a strong effect on both outcome variables (see, for example, Melitz and Ottaviano 2008). Using information from the World Bank surveys, we can address this issue. In particular, we define a competition dummy variable that takes a value of one for firms that reported having five or more competitors in their market. Country fixed effects are denoted by μ_c, the residual is given by $\varepsilon_{j,i,c,t}$ and standard errors are clustered at the country level.[19] The main effect of interest is given by β_4 and β_5 on the interaction terms. These indicate the differential impact of liberalization on firms that were credit-constrained in the initial period, that is before changes in tariff rates. Note that we check for a non-linear effect by adding the squared term of tariff changes.[20] Because all of outcome variables $Y_{j,i,c,t}$ are dummy variables, we use a probit estimator although a logit estimator yields very similar results. Estimation of the marginal effects at mean values of covariates takes into account prior work by Ai and Norton (2003) and Norton et al. (2004). Finally, it is worth noting that we focus the discussion of the results mainly on estimates of β_4 and β_5 on the interaction effects. The key hypothesis we test is whether

18 To highlight the importance of the control variables, we point out that 13.4% of domestically owned companies report being credit-constrained, while the share is just 7.3% among those with foreign ownership.

19 Note that we add industry fixed effects in the robustness section. Given the small number of observations in regressions with R&D-related outcomes, we prefer the specification without industry fixed effects. However, as shown in table 6, our findings are robust to controlling for industry-specific effects.

20 While we do not explicitly address this aspect in our theoretical model, it seems plausible that tariff changes have a statistically significant impact only if they are of non-negligible magnitudes. In order to control for outlier observations, we tested the robustness of our findings by removing the 5% extreme values. This leaves results of table 5 largely unchanged but renders estimated coefficients of table 3 insignificant.

$$\left.\frac{\partial Y_{j,i,c,t}}{\partial \Delta T_{j,i,c,t}}\right|_{CC_{j,i,c,t-1}=1} = \left.\frac{\partial Y_{j,i,c,t}}{\partial \Delta T_{j,i,c,t}}\right|_{CC_{j,i,c,t-1}=0}, \tag{10}$$

that is, whether the effect of a tariff change on firms is the same for financially constrained and non-constrained enterprises. While we focus on β_4 and β_5, we acknowledge that is more complex to indicate whether there is a significant difference in the impacts or that this difference matters over the range of relevant tariff cuts. Hence, we provide non-linear estimates of the effect of credit constraints across the full spectrum of tariff cuts in figure 2.

To identify causal effects of trade liberalization, the change in tariff rates has to be exogenous. Although it is possible that firms influence policies through lobbying it is unlikely that many firms in our sample had sufficient leverage to manipulate national policies. For one thing, the median firm in our data set has only 29 employees. In addition, changes in this policy dimension are often induced by international policies such as free trade agreements or regional organizations. The Peruvian liberalization between 2006 and 2010, for example, was related to the negotiations of the *Peru Trade Promotion*

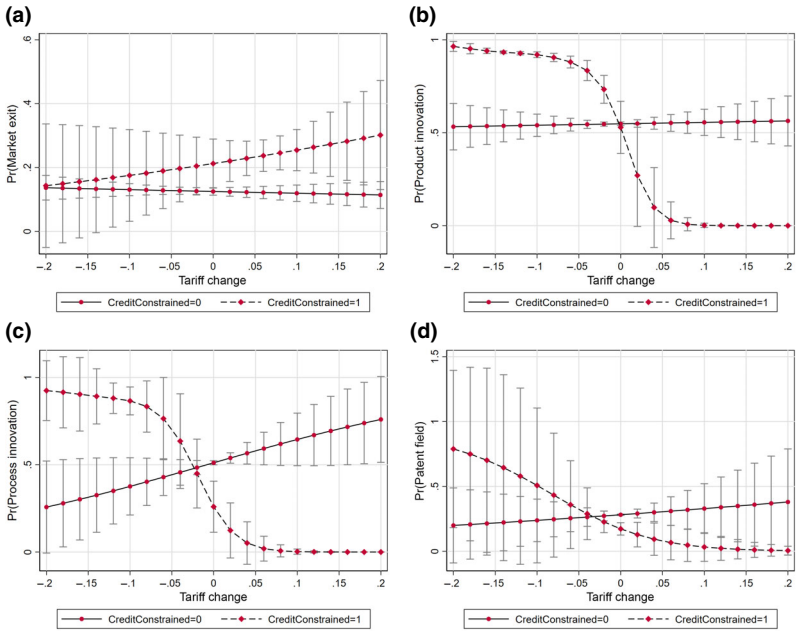

FIGURE 2 Marginal effect of credit constraints by tariff changeM
NOTES: The figures show the marginal effects of credit constraints at different levels of tariff changes, ranging from an increase of 20% to a reduction of 20%. Tariff cut is calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. Market exit is defined as business failure including businesses not found in 2010. All three measures of R&D are dummy variables for innovative activity in the three years prior to 2010. Confidence intervals at the 95% level are shown based on standard errors clustered at the country level.

TABLE 4
Endogeneity of tariff changes

Mean of dependant variable	Tariff cut (in %)			
	−0.944			
	(1)	(2)	(3)	(4)
Firm size 2006	0.159	−0.551	−0.373*	0.071
	(0.236)	(0.584)	(0.187)	(0.103)
Firm age 2006	0.001	−0.003	0.012	−0.001
	(0.015)	(0.014)	(0.009)	(0.007)
Foreign ownership 2006		−0.136	0.154	−0.295
		(1.115)	(0.586)	(0.502)
Log annual sales 2006		0.402	0.387	0.077
		(0.541)	(0.254)	(0.151)
Exporter 2006		−0.153	−0.784	−0.111
		(0.629)	(0.828)	(0.571)
Credit constr. 2006		−0.266	−0.099	−0.099
		(0.324)	(0.122)	(0.134)
Fixed effects			Country	Country, industry
Observations	2,976	2,969	2,969	2,969
R-squared	0.001	0.011	0.412	0.568

Agreement with the USA, signed in April 2006. We also provide a simple test for endogeneity by regressing tariff changes on a number of firm characteristics. In particular, we fit the linear regression

$$\Delta T_{j,i,c,t} = \beta CC_{j,i,c,t-1} + \gamma \mathbf{X}_{j,i,c,t-1} + \varepsilon_{j,i,c,t}, \tag{11}$$

where $\Delta T_{j,i,c,t}$ is the tariff change for a specific ISIC code at the four-digit level faced by firm j in industry i and country c between 2006 and 2010. Firm characteristics as of 2006 are summarized as $\mathbf{X}_{j,i,c,t-1}$, the residual is given by $\varepsilon_{j,i,c,t}$ and standard error term are clustered at the country level. Table 4 provides the estimates.

Basically none of the employed firm variables shows a significant effect on tariff changes in the respective ISIC code. In particular, firm size and age in 2006 do not appear to explain liberalization patters.[21] Most importantly, firms with financial constraints in 2006 are not more likely to be subject to tariff changes.[22] Nevertheless, we cannot fully rule out that liberalization was—in some unobserved ways—influenced by firms or accompanied by other policies. Hence, we interpret our results as robust correlations rather than causal effects. It is, however, noteworthy that any endogeneity would make it more

21 The only exception is a weak significant coefficient on firm size in column (3). However, once we add industry fixed effects, the coefficient loses significance and even turns positive.

22 With very few exceptions, none of the industry dummy variables shows a significant coefficient. Not surprisingly, however, most of the country dummy variables are significant.

difficult to observe the patterns we see in the data. In particular, policymakers are less likely to lower tariffs in sectors struggling because of financial constraints.

4.2.2. Findings for market exit

In a first step, we examine the joint effects of trade liberalization and credit constraints on market exit. As explained earlier, we add a measure for the degree of competition to the list of control variables because it is one of the key drivers of market exit. In all regressions, we apply the broad definition of market exit, which includes firms that could not be contacted for reasons that indicate business failure. The estimation results are shown in the first two columns of table 5.

Our estimates suggest that a tariff reduction among firms facing credit constraints in the initial period led to increased market exit. Reducing tariff protection by one percentage point for these firms is associated with a 0.5 percentage point increase in the probability of leaving the market. Larger tariff cuts are associated with increasing effects as indicated by the significant coefficient on the squared term. The overall quantitative impact of the nonlinearity can be assessed in figure 2. This could be interpreted in the sense that firms can absorb small shocks but leave the market in case of large disruptions.

A potential drawback of adding quadratic terms is the fact that the results could depend on outliers. To check for this we proceed in two steps. First, we removed the 5% extreme values as a robustness analysis. This leaves results of table 5 largely unchanged but renders estimated coefficients of table 3 insignificant. Second, we run the regressions without the squared term, the results are shown in tables A5 to A8 in the online appendix. Tariff cuts remain to have a negative effect but the coefficient loses significance for some specifications.

4.2.3. Findings for quality upgrading

For those firms who do not leave the market, we expect to see a negative effect of liberalization on credit-constrained firms' propensity to develop innovative products and production processes. We provide the respective regressions in columns (3) to (8) of table 5. Concerning the impact of tariff reductions itself we find some (weak) evidence of a positive impact on R&D-related activities. This is in line with previous research (Lileeva and Trefler 2010, Bustos 2011b).[23] The more important finding for our study, however, is the effect of

23 One surprising finding in table 5 is the positive coefficient on credit constraints in columns (3) and (4). We attribute this to two possible causes. First, there might be a selection effect due to companies with severe problems obtaining credit leaving the market: firms with credit constraints are about twice as likely to exit the market. Second, self-reported financial constraints can signal that companies have demand for credit, for example to invest in R&D to innovate products.

TABLE 5

Main results – Exit and innovation

	Exit		Innovate product		Innovate process		File patent	
Mean of dependant variable	0.14		0.54		0.56		0.26	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tariff cut	−0.115	−0.054	0.605	0.094	0.818	1.526	0.854*	0.495
	(0.233)	(0.103)	(0.496)	(0.373)	(0.586)	(0.966)	(0.514)	(0.870)
Tariff cut sq.	0.008	0.012***	0.042	−0.027	0.187***	0.133***	0.073	0.070
	(0.011)	(0.004)	(0.060)	(0.038)	(0.054)	(0.029)	(0.048)	(0.048)
Credit-constrained	0.063	0.070	0.167***	0.157**	−0.021	−0.069	−0.041	−0.020
	(0.044)	(0.046)	(0.063)	(0.070)	(0.191)	(0.169)	(0.055)	(0.061)
CC×Tariff cut	0.540**	0.490	−9.933***	−10.412**	−11.007*	−10.110**	−2.948*	−4.252**
	(0.279)	(0.345)	(4.343)	(4.581)	(6.513)	(5.453)	(1.873)	(2.020)
CC×Tariff cut sq.	0.060***	0.069***	−1.703***	−1.754***	−3.838	−3.139	−1.010	−1.280
	(0.019)	(0.027)	(0.598)	(0.623)	(4.961)	(4.400)	(0.744)	(0.792)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects		Country		Country		Country		Country
R-squared	0.058	0.104	0.046	0.081	0.046	0.103	0.088	0.094
Observations	1,025	1,025	236	236	197	197	361	361

NOTES: The table shows eight separate probit regressions using different dependent variables as indicated in the top row. Coefficients show marginal effects at the means of covariates. Tariff cut is calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. Control variables comprise firm size, firm age, foreign ownership, competition, share of sales of main product, exporting status, share of foreign inputs and share of labour costs. Standard errors are clustered at the country level and shown in parentheses. Significance levels are as follows: *0.10, **0.05, ***0.01. CC = credit-constrained.

trade liberalization on credit-constrained firms. Irrespective of which R&D measure we use as outcome variable, we observe a significant negative coefficient on the interaction term of trade liberalization and credit constraints. The significance of the coefficients is also present—and in some cases even larger in magnitude—when adding country fixed effects to control for unobserved factors. Estimation results suggest that a one percentage point decrease in tariff protection reduces constrained firms' probability of introducing innovative products or processes by about 10 percentage points. Moreover, the probability of filing a patent is reduced by three to four percentage points among these firms. Unlike in the case of market exit (columns (1) and (2)), there is only mixed evidence of a non-linear effect of larger tariff cuts. This may, however, be due to the limited number of observations in the last four regressions.

Overall, these findings support our theoretical predictions and suggest that limited access to finance not only distorts exporting behaviour—as has been shown in previous research—but also correlates with R&D-related activities at the firm level. In figure 2, we illustrate our results.

The four plots indicate the marginal effects of credit constrains on our outcome variables, depending on the magnitude of tariff change ranging from plus to minus 20 percentage points. Panel (a) shows that firms facing credit constraints are increasingly likely to exit the market when being exposed to tariff reductions. This is not the case with unconstrained enterprises. Panels (b), (c) and (d) illustrate the sharp difference between financially unconstrained and financially constrained firms with respect to innovative activity. While the former respond positively to tariff cuts, the latter sharply reduce R&D efforts.

We can relate this finding to prior research on trade liberalization and firm-level R&D investment (Atkeson and Burstein 2010, Lileeva and Trefler 2010, Bustos 2011b). The observation that firms facing reductions in tariffs increase their investment in technology upgrading has been established before. The very different response by credit-constrained firms, however, is a novel finding.

4.3. Alternative explanations and robustness tests

In order to verify our empirical findings we conduct a number of robustness tests. This addresses several potential concerns about our main findings. First, we examine whether better access to imported inputs alters our findings on the impact of trade liberalization on market exit and innovation. Subsequently, we examine whether the estimates are robust to changes in the econometric approach. Finally, we address potential conceptual concerns.

Imported inputs. Trade liberalization exposes firms to the global market. However, it also improves firms' access to cheaper and better inputs. In our panel data set, about 78% of firms use inputs from abroad. We, thus, would like to take account of the input-channel when estimating the impact of

tariff cuts on market exit and innovation through the credit constraints channel. Controlling for this alternative channel, however, is impeded by the lack of information on which products firms import. The World Bank Enterprise Surveys asks managers only if inputs are imported from abroad and the share of foreign inputs. To alleviate this problem, we use information on data from an input–output table across sectors to construct sector-specific input tariffs. Because comparable input–output tables are not available for all countries and years in our data set, we take the OECD input–output table for Chile in 2011 and combine it with country-specific yearly tariffs from our data set to construct country–industry–year-specific input tariffs.

This provides us with a proxy variable that indicates whether a firm in our data set experienced a change in the tariffs on the inputs it sources from abroad. We add this variable and its interaction with the share of foreign inputs to the set of control variables in our main empirical model. Estimating equation (9) with these additional controls yields the results of table A4 of the online appendix. The estimates suggest that controlling for input tariffs does not alter our main finding that credit-constrained firms are more likely to exit the market and less likely to innovate when being exposed to trade liberalization. As for the input tariffs, the results show little statistical correlation with market exit or innovation.

Industry-specific differences. Following prior research by Rajan and Zingales (1998), we take into account the idea that different industries rely differently on external finance. As a result, firms in sectors with high dependence on external funding are more vulnerable to capital market frictions. We address this by adding industry fixed effects to the right-hand side of equation 8.

Estimates in panel A of table 6 show that when adding dummy variables for each industry, we still obtain coefficients on the interaction term of credit constraints and tariff cuts similar to those in our main estimation.[24]

Because of the small sample size, adding many fixed effects may, however, be problematic. With data from seven countries and more than 40 industries, we lose several degrees of freedom in the most demanding regression. While the coefficients keep their signs, they are no longer significant, see table A9 in the online appendix. To circumvent this we run a conditional (fixed-effects) logistic regression to test whether our estimates are robust (Chamberlain 1980). Results in panel B indicate that for all four outcome variables we still observe similar coefficients.

Small firms. It is a well-established fact that a firm's size is strongly related to its probability of being financially constrained. In fact, our model predicts that poorer entrepreneurs run smaller firms and face more difficulties

24 When adding country and industry fixed effects as well as their interaction with credit-constrained dummy, coefficients keep their expected sign but are statistically insignificant due to the small sample size.

TABLE 6

Robustness and specification tests

	Exit	Innovate product	Innovate process	File patent
Mean of dependent variable	0.14	0.54	0.56	0.26
	(1)	(2)	(3)	(4)
A. Country and industry fixed effects				
Credit-constrained×Tariff cut	0.567*	−8.942	−10.075*	−5.516**
	(0.339)	(5.978)	(6.955)	(2.758)
Credit-constrained×Tariff cut sq.	0.070***	−1.547**	−3.679	−1.259
	(0.027)	(0.709)	(4.828)	(0.945)
Observations	1,008	220	193	352
B. Conditional logit estimation				
Credit-constrained×Tariff cut	0.806	−16.139**	−14.408*	−2.390**
	(0.765)	(6.843)	(8.649)	(0.988)
Credit-constrained×Tariff cut sq.	0.094**	−2.324***	−4.404	−1.013
	(0.039)	(0.802)	(7.391)	(0.810)
Observations	1,025	236	197	361
C. Horse race vs. "small firm"				
Credit-constrained×Tariff cut	0.409	−10.476**	−10.506*	−4.506**
	(0.522)	(4.545)	(5.739)	(2.112)
Credit-constrained×Tariff cut sq.	0.065**	−1.785***	−3.317	−1.264
	(0.026)	(0.616)	(4.513)	(0.809)
Small firm×Tariff cut	0.210	−0.251	1.968	−1.029*
	(0.525)	(1.105)	(1.902)	(0.597)
Small firm×Tariff cut sq.	0.008	−0.097	0.471***	0.132**
	(0.017)	(0.075)	(0.154)	(0.051)
Observations	1,025	236	197	361
D. Weighted average tariff rates				
Credit-constrained×Tariff cut	1.074**	−2.747*	−11.255**	−7.261**
	(0.406)	(1.539)	(5.714)	(2.593)
Credit-constrained×Tariff cut sq.	0.114***	−0.280	−1.521***	−0.431**
	(0.044)	(0.195)	(0.565)	(0.181)
Observations	1,008	220	193	352

NOTES: The table shows 16 separate regressions using different dependent variables as indicated in the top row. Coefficients show marginal effects at the means of covariates. Except for part B, we always apply a probit estimator. Tariff Cut is calculated as the four-digit ISIC level tariff in 2006 minus the tariff in 2010. In part D, tariff cut is based on weighted (instead of simple) tariff rates. All estimations include country fixed effects and control variables as in the baseline regression (cf. table 5). Standard errors are clustered at the country level and shown in parentheses. Significance levels are as follows: *0.10, **0.05, ***0.01.

in terms of access to credit. This is in line with research by Aghion et al. (2017) and also supported by our data. The status of being financially constrained is more prevalent among small firms. The numbers indicate that small firms are 36% more likely to be credit-constrained than large firms. Moreover, there is evidence of serial correlation in the sense that firms reporting credit constraints in 2006 are much more likely to do so in 2010. The fact that firm size and access to credit are correlated may cause a problem for our empirical analysis. It could be argued that our dummy variable for being credit-constrained ($CC_{j,i,c,t-1}$) captures other characteristics of small,

unproductive firms. If so, the effects reported above may not be driven (solely) by the importance of financial frictions. In a Melitz (2003) model, the adverse effects of trade liberalization work through upward pressure on wages. In our model, they work through a rise in the interest rate and a fall in markups, corresponding to a loss of profitability.

We address this concern by running a "horse race" between access to credit and being a small firm as proxy for low productivity. In particular, we use a dummy variable for being a small firm in 2006 and use it in the same way as our indicator of being credit-constrained. In case it is indeed access to finance that determines firms' behaviour, only the interaction term with credit constraints should turn out to be significant. The results in panel C of table 6 show that the interaction terms with the small-firm dummy are mostly insignificant, while the credit-constrained dummies remain significant and similar in magnitude to the baseline regression. We interpret this as evidence that it is indeed access to credit causing differential responses to trade liberalization.

Weighted average tariff rates. Another robustness test concerns the measure of trade liberalization. Throughout our estimations we used the simple average tariff rate at the four-digit ISIC code to determine whether firms were subject to a reduction in tariff protection. In panel D of table 6 we instead use the weighted average tariff rate. Overall, the results are very similar to our baseline estimates.

Supply of and demand for credit. A potential problem arises when firms self-report whether they regard credit constraints to be a major obstacle to their business activities. High net worth firms, for example, could be "constrained" due to a positive productivity shock. In contrast, a firm that has little investment opportunities may not report access to credit being a problem. Our theoretical and empirical work considers credit constraints as reflecting demand for a loan that is not met by banks. Using our data set, we can investigate why firms report access to finance as a major problem.

During the survey, all firms in our data were asked the question, "If in fiscal year [year], this establishment did not apply for line of credit or loan, what was the main reason?" Firms could answer that they did not need a loan or select one of five reasons for why they did not apply for a loan. Regression results shown in table A1 of the online appendix reveal that our measure of credit constraints is highly correlated with interest rates being too high, complex application procedures and negative expectations about getting a loan. Further estimates indicate that larger, older, or foreign-owned firms are less prone to be credit-constrained. We take this as evidence that our measure of credit constraints actually reflects the unmet demand for loans.

Heterogeneous financial development. The countries in our sample differ substantially with respect to their economic development. We expect to see the impact of credit constraints and tariff reductions to be magnified if capital market imperfections are more severe. In our model this would refer to a decrease in λ, the parameter governing the degree of imperfection of the

capital market. To test this, we split our sample and run the same regressions as before using only firms from less-developed countries. Drawing on data from the International Monetary Fund, the GDP per capita (PPP) as of 2013 differs substantially among the seven countries of our sample: Argentina $22 300, Bolivia $5 900, Chile $22 500, Colombia $12 800, Paraguay $8 000, Peru $11 600, Uruguay $19 700. We can use this information and restrict the sample to firms in Bolivia, Colombia, Paraguay and Peru.[25] This leaves us with roughly half the number of observations. Note that in our survey data from the World Bank, firms located in Colombia and Paraguay are most likely to report difficulties getting access to credit. This supports the use of income per capita as a proxy for the development of a country's financial sector.

When reducing the sample to the least developed countries and running the same regressions as in table 5, we find support for our hypothesis. The point estimates for the joint impact of credit constraints and tariff cuts are larger in the restricted sample. We provide all estimation results using the restricted sample in table A2 of the online appendix. Significance levels, however, are obviously lower given the substantial reduction in the number of observations.

Financial crisis. A final concern we address is the impact of the 2007–2008 global financial crisis. Because we employ data from the years 2006 and 2010, the question arises how the crisis affects our empirical findings. In our empirical analysis we explore the differential impact of trade liberalization among firms that faced credit constraints in 2006 and those who did not. Thus, we define treatment and control group based on firm characteristics determined before the stock market crash. The shock to the financial system in 2007, however, affected the countries in our sample. We can illustrate this by considering annual growth rates of real GDP. The numbers in table A2 of the online appendix show that on average the annual growth rate in 2008 and 2009 was three percentage points lower than in the two years before the financial crisis. To address the heterogeneity across countries, we add country fixed effects to all regressions. Moreover, if trade policy was affected by the financial crises the most plausible bias would make it more difficult to observe the patterns in the data that we document: policy-makers are less likely to lower tariffs for firms in sectors that are vulnerable to shocks in the capital market.

25 Note that although we split the sample by GDP per capita, we could also use various financial indicators such as bank accounts per 1,000 adults, credit to private sector as a share of GDP, financial system deposits as a share of GDP, or the stock market capitalization to GDP. All of these indicators are highly correlated with income per capita. Hence, selecting the sample of less-developed countries based on these indicators would leave us with a similar or even identical sample.

5. Conclusion

In this study, we explore heterogeneous responses to trade liberalization at the industry and firm level. As illustrated by a simple theoretical model, we expect financially constrained firms to have a higher probability of leaving the market after liberalization. For surviving firms, the model suggests limited investment in quality-upgrading when firms are financially constrained and face tariff cuts. Using firm level survey data from seven Latin American countries for the period from 2006 to 2010, we assess these predictions empirically. In line with our theory, we find that financially constrained firms being subject to liberalization are associated with more market exits, fewer product and process innovations and fewer filed patents. This impact is shown to be robust to the inclusion of various control variables and country and industry fixed effects. Moreover, the findings are not driven by any single country or the specification of our regression equation.

Our results add another dimension to the evidence on how financial constraints affect and distort firm behaviour. In the presence of imperfect capital markets, adjustments after trade liberalization are limited at the firm level. As a result, gains from openness can be reduced in developing countries. This adds to the recent literature arguing that low aggregate total factor productivity—especially in developing countries—is the result of a resource misallocation at the firm level (Hsieh and Klenow 2009, Song et al. 2011). In a broader sense our findings suggest that reductions in the magnitude of one distortion (here: tariffs) do not necessarily lead to a welfare gain if there are other distortions (credit market imperfections) in the economy (Bhagwati 1971). Furthermore, we contribute to the literature discussing potential negative effects of trade liberalization (Goldberg and Pavcnik 2007, Edmonds et al. 2010).

On a general level, our analysis points to the fact the that there is an interesting parallel between labour market and financial market frictions shaping the impact of trade liberalization. With-in-country market frictions play a key role in how fast and to what degree the gains from trade can be reached and how they are distributed. Two important aspects of opening markets and the potential gains from trade are, first, the reallocation of resources and, second, the emergence of scale effects. While labour and financial market frictions affect both of them, labour market frictions are likely to be more relevant in the former (e.g., Davidson, Matusz and Shevchenko 2008). Our model outlines that financial market frictions could be more relevant when we consider how much an economy may capitalize on scale effects.

In this sense, the findings of our study are linked to policy implications. In the presence of credit constraints, adjustments at the firm level can be impaired. Hence, optimal policies must take into account the fact that sectors differ in their reliance on external finance and therefore in their ability to adjust their production to a post-liberalization environment. The importance of credit constraints with respect to international trade has been emphasized by Manova et al. (2015). Their findings suggest that FDI can reduce liquidity

constraints at the firm level. Moreover, firms' credit rating has been shown to affect their propensity to engage in international trade (Muûls 2015).

There are a number of caveats to our conclusions. First and foremost, tariff reductions across sectors are typically non-random. As a result, identifying causal effects of trade liberalization at the firm level remains challenging. We provide empirical evidence showing that firm characteristics such as size and age in the initial period do not correlate significantly with subsequent tariff changes. In addition, firms with credit constraints before trade policy changes were not more likely to be subject to trade liberalization. Moreover, we add country and industry fixed effects to control for unobserved factors. All of this does not affect our empirical findings. Regarding the magnitude of welfare gains from trade, however, Dehejia and Panagariya (2016) suggest that there may be positive spillover effects from liberalization in manufacturing to gross value added, wages, employment and worker productivity in services. Hence, exploring firms' decision to move from manufacturing to service as a response to trade liberalization appears to be a promising field for future research.

Supporting information

Supplementary material accompanies the online version of this article.

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